APPENDIX (3)a: Substitute Specification (Clean Copy)

A PORTABLE POLYPHONIC BUTTON-FIELD MUSICAL CONTROLLER WITH THUMB-CONTROLLED EFFECTS

FIELD OF THE INVENTION

The present invention relates to musical instruments and, in particular, to a polyphonic electronic musical instrument and controller.

BACKGROUND OF THE INVENTION

There exists a large range of known conventional or acoustic musical instruments such as pianos, brass, reed and string instruments. The piano has polyphony (i.e., can play many notes at once) but few expressive controls, these being velocity sensitivity, reduced string damping (sustain or loud pedal) and increased string damping (soft pedal). Other types of acoustic instruments can offer more expressive control through the interaction of lip muscles and mouthpieces and reeds, fingers or bows on strings, but the polyphony of these instruments is low (often being monophonic).

Different forms of electronic synthesisers and MIDI input controllers have also tried to emulate a wide variety of acoustic instruments and add a limited number of additional expression devices. On keyboard synthesizers, for example knobs, sliders, and wheels are often provided to allow the player to enhance the expression of the selected notes. However, the player must usually stop selecting notes with one hand to manipulate the expression controls with that hand. This trades away polyphony for expression. Another disadvantage of the piano style keyboard used on pianos and most polyphonic electronic instruments is the size and weight of the input or control surface (the keyboard).

One of the major advantages of the piano keyboard is that its keys are all visible to the pianist when playing, which helps novices locate and select its keys. As a counter-example, a concertina's button-fields are not visible to the concertinist when playing, since the concertina's button-fields are (a) usually facing away from the concertinist's eyes, and (b) usually in motion at either end of the concertina's

bellows. This is a significant impediment to learning to play the concertina compared to the piano.

It is therefore an object of the present invention to provide a new musical instrument which provides relatively greater expressiveness and polyphony than existing instruments, and ideally also providing ease-of-learning benefits.

SUMMARY OF THE INVENTION

With the above objects in mind the present invention provides a portable user operated electronic music controller which comprises, for a given hand, a polyphonic finger-operated button-field and a thumb-operated expressive control.

On piano-style keyboards, all of the performer's digits, including thumbs, share in note-playing duty, and this is also true of table-top button-field instruments. Squeezeboxes such as the concertina provide a small button-field controlled by the performer's fingers, but devote the performer's thumbs (and, in the English concertina, the performer's pinkies) to the duty of supporting the instrument's hand-units and working its bellows. In all these instruments the player's thumbs have duties which preclude their being devoted to controlling musical expression.

By using a concertina-like polyphonic button-field which can be spanned by the fingers of a single hand, the thumb is freed from note-playing duty. By using electronic means for sound generation, the thumb is freed from bellows-control duty. By using a forearm brace or other non-digit means of supporting a hand-held instrument, the thumb (and fingers) is freed from instrument-support duty.

Freeing the thumb from these other duties enables the thumb to be devoted to the control of expressive effects, while the fingers are free to play more than one note at a time on their button-field, thereby providing an expressive polyphonic instrument.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a top view of a musical instrument in accordance with a first possible embodiment of the present invention;

Figure 2 is a left side view of the musical instrument shown in Figure 1;

Figure 3 is a front view of the musical instrument shown in Figures 1 and 2;

Figure 4 is a rear view of the musical instrument shown in Figures 1 to 3;

Figure 5 is a perspective view of a musical instrument in accordance with a second possible embodiment of the present invention, shown in a "closed" or folded form position;

Figure 6 is another perspective view of the musical instrument shown in Figure 5;

Figure 7 is a perspective view of the musical instrument shown in Figures 5 and 6, now shown open in an unfolded (substantially coplanar) form position;

Figure 8 is a front/side view of a musical instrument in accordance with a third possible embodiment pf the present invention, shown in a closed (folded) position.

Figure 9 is a front/side view of the musical instrument of Figure 8 shown in an open (unfolded) position.

Figure 10 is a block diagram of the data flow between the different elements of all of the modules in the instrument of an embodiment;

Figure 11 shows a casing for housing the musical instrument in accordance with another aspect of the present invention.

Figure 12 is a block diagram of the data flow between the electronic elements of the instrument's casing of Figure 11.

DESCRIPTION OF PREFERRED EMBODIMENT

Definitions

A "note" or "musical note value" is one of a set of predetermined musical notes, defined variously by proprietary data formats and common industry standards such as MIDI (Musical Instrument Digital Interface) and OSC (Open Sound Control).

A "monophonic" music control interface enables the performer to specify only one note at a time.

A "polyphonic" music control interface enables the performer to specify more than one note at a time. (A polyphonic interface can be used to drive a monophonic tone generator, in which case the performer can specify more notes at a time than the tone generator can generate.)

A "button" is a stud or bounded surface.

A "note-identifier button" or "note-identifying button" is a button that corresponds to a predetermined note.

A "button-field" is a bounded two-dimensional array of at least five note-identifier buttons (not all in the same line).

A "button-arrangement" or simply "arrangement" is the specific spatial pattern of buttons within a button-field.

A "layout" is a pattern of association between musical notes and a button-field's buttons.

A "button-field instrument" is a musical instrument including at least one such button-field, just as a musical instrument including at least one piano-style keyboard is a "keyboard instrument."

A "static" button-field arrangement is fixed at the time of manufacture, whereas a "dynamic" button-field arrangement can be changed at the user's discretion.

A "musical effect" is a variable such as loudness, pitch bend, modulation, brightness, etc., which affects the sound of a note without changing its musical note value.

A "per-field effect" is a musical effect that applies to substantially all of the notes of at least one button-field.

A "note-actuation variable" is a variable that is controlled by the physical actuation of a note-identifying button, such as key velocity, polyphonic aftertouch, or channel pressure.

A "note-actuation effect" is a musical effect to which a note-actuation variable is mapped.

A "finger-span" is the region of a surface that can be reached by at least one of the fingers of a given hand, when said hand's forearm is fixed relative to said surface (but said hand's wrist is free to rotate).

A "thumb-span" is the region of a surface that can be reached by the thumb of a given hand, when said hand's forearm is fixed relative to said surface (but said hand's wrist is free to rotate).

A "finger-span button-field" is a button-field in which substantially all of its note-identifier buttons are arranged within a single hand's finger-span.

A "finger-activated controller" is a finger-span button-field, or one or more finger-activated controls other than a button-field, or a combination thereof, all within a single hand's finger-span.

A "thumb-activated controller" is one or more controls that are designed to be operated by a single thumb, all within said thumb's thumb-span.

A "digit-activated controller" is either a finger-activated controller or a thumb activated controller.

A device is "hand-held" if it is designed to be supported, stabilized, and positioned solely by the arm, its hand, and/or its digits. A brace can be used to affix such a hand-held instrument to the hand, wrist, or forearm, within the scope of this definition. A neck-strap can be used to relieve the arm/hand/digits of supporting the weight of the device during extended periods of use, within the scope of this definition. The ability to affix such a hand-held instrument to a stand, or to perform with it while it is supported by a table or stand, does not detract from its being considered to be a hand-held device, so long as its design facilitates use when supported, stabilized, and positioned solely by the arm/hand/digits as described above.

Description

The basic concept of the present invention combines a hand-held electronic musical instrument, at least one finger-span button-field positioned for use by the

fingers of one hand, and at least one multi-variate control positioned for manipulation by said hand's thumb. Ideally the thumb control would be a multi-variate controller.

In a first embodiment, there are separate finger-span button fields for each hand, and separate controls for each thumb. Each separate button-field is arranged to provide the maximum number of buttons within its hand's finger-span, with few other finger-activated controls. Preferably, the button-arrangement facilitates the simultaneous pressing of one, two, or even three adjacent buttons with a single fingertip, to sound respectively one, to, or three notes.

Also, additional controls are positioned to be manipulated by the players' thumbs, primarily for the purpose of controlling per-field effects, thereby adding musical expression to the notes being played with the fingers. Such effects include but are not limited to pitch bending, brightness, portamento time, reverb depth, and other such musical effects

This combination allows both a high degree of polyphony and a high degree of musical expressiveness, in an instrument that can be remarkably small and light. Being small and light makes the instrument easier to play for extended periods, and opens the door to other benefits which are beyond the scope of the present invention.

As is known to those versed in the art of electronic music, many electronic instruments provide different modes of operation. In a mode that might be called "performance mode," for example, pressing a finger-operated button might sound a note, whereas in a mode that might be called "setup mode," pressing this same button might select a musical effect variable for modification, select a different sound for the instrument, or perform some other function quite distinct from its function in "performance mode." The transition from one mode to another can be effected through the manipulation of the instrument's thumb controls, although other means such as foot-controlled switches or breath-pressure controls, known to those familiar with the art, could be used.

Referring initially to Figure 1 there is shown a first embodiment of an electronic musical instrument 1, according to the present invention. The body of the instrument includes two main portions, a rearward transverse portion 2, which is held in the palms of the player's hands, and a tapering forward vertical portion 3, which forms the finger/instrument interface.

Buttons can be provided on any or all of the surfaces 4, 6 and 8 for the fingers of the player's left hand and on any or all of the surfaces 5, 7 and 9 for the fingers of the player's right hand.

It should be noted that the primary purpose of the finger-activated controller is to provide signals indicative of the notes the player wishes to produce, along with note-actuation effect signals such as attack velocity, release velocity and pressure or after-touch. The finger-activated controllers can also include areas, buttons, sliders or other forms of input control device to permit per-field signals such as pitch bend and modulation. For example, an octave switch can be provided as part of a finger-activated controller to transpose the set of pre-determined notes of the controller output by whole octaves.

A jack 12 is shown, which could be used for audio output such as for headphones. The headphone jack could be positioned at any convenient point on the instrument and could additionally have a volume control input alongside (not shown) or use one of the other input controllers on the instrument.

Another possible input device is a breath controller which can be used in combination with the finger-activated controller, the breath controller producing at least one or more per-field effects. Conventional foot switches and continuously variable foot pedals can also be used, however these limit the player to a position while using them and provide no benefit in control over the use of the thumb-activated controllers so are generally unnecessary encumbrances. These jacks are general-purpose, however, and could be used to input data from alternative controllers such as elbow-angle sensors, bagpipe-bag air-pressure sensors, or any other sensor.

Also shown on the instrument in Figure 1 are thumb-activated controllers 14 and 15. Each thumb-activated controller can include one or more input devices which can be of any known type including buttons, sliders, rotary adjusters, proximity sensors, or any positional input devices such as joysticks, touch pads or other control surfaces. The thumb-activated controllers shown in figure 1 are multiple input controllers. Although it is possible that only one thumb controller be provided to control a single per-field effect value, it is preferable to provide at least one thumb controller for each thumb.

Although the thumb-activated controllers are primarily provided to generate per-field effect values, they can, in addition or alternatively, be configured to generate music note values, or programmed to perform other functions. For example, a number of buttons could be provided and programmed to produce different individual (or patterns of) music note values corresponding to say a base line, or to produce chords used in the piece of music being performed.

It should be understood that the finger-activated controllers and the thumb activated controllers can each produce music note data, note-actuation data, per-field effect data, and instrument metadata.

The finger-activated controllers and the thumb-activated controllers can be designed to generate music data in a proprietary format or an industry standard format such as, for example, the Musical Instrument Digital Interface (MIDI) format or the Open Sound Control (OSC) format. The signals from the different controllers can be combined into a single data stream which may have a number of channels (like the 16 used in MIDI) with each finger- or thumb-activated controller (or even assignable portions of each finger- or thumb-activated controller) being assigned to any one or more of the available channels. Alternatively, the finger- and thumb-activated controllers can communicate the values to other electronic devices inside or external to the electronic musical instrument which in turn then generate data in a standard format. Alternatively, or additionally, the finger-activated controllers and the

thumb-activated controllers can communicate with other electronics inside and/or external to the instrument which generate audio signals.

A sequencer function can be provided in the electronics of the instrument, or in the electronics of any other device which communicates with the instrument.

Although the musical instrument can be plugged into an external display unit, or another device with a display, or it can include displays as part of the finger- or thumb-activated controllers, it may be desirable in some embodiments to provide a dedicated display screen 16. The display screen can be used to indicate instrument voices selected at the time, music effects currently in use, the part of a music score currently being played, or other such data whilst the user is playing the instrument. Alternatively, it can be the sole display available to the user, so it may display any data and may itself be touch sensitive, thus could be both a display device and a general-purpose input device

The T-shape of the electronic musical instrument of Figures 1, 2 and 3 is designed to allow the user to operate the finger and thumb-activated controllers around a convenient electronic package including a motherboard and at least one daughterboard located at right angles to each other. The motherboard can be located in the rearward transverse portion 2 of the instrument, along the line shown at 17 in Figure 2. Then the daughterboard (such as a tone generating sound card) can be plugged into the motherboard through the slot 18 in the front of the instrument as shown in Figure 3. Also shown in figure 3 is a further slot 19 for a memory module. This memory module could be used to import data relating to audio synthesis of different instruments, to record sequencer data of musical composition or performances, or for the importing, storing and/or exporting of any other data.

A multi-purpose connection port 20 is shown on the front of the instrument (shown in the example in Figure 3 adjacent to a Universal Serial Bus symbol, but this can be any standard or proprietary format port). The port is provided to transmit, to or from the instrument, power, music note values, music effect values, music

industry standard format data, audio signals, instrument metadata such as sound generation model parameters or samples, or any other data.

The power button 21 for the instrument is shown next to a direct audio out jack 22. The direct audio out jack could be replaced or complemented by a digital audio out connector.

Additional finger activated control devices 23 and 24 can be provided on the front faces of the rearward transverse portion of the instrument. The additional finger-activated control devices 23 for the right hand and 24 for the left hand, can include similar devices or a combination of devices such as buttons, joysticks, sliders and/or touch pads.

A power supply connection can be provided for supplying power to the musical instrument for operation and charging internal batteries. It can be advantageous to provide this dedicated power supply connection if the multi-purpose connection port 20 is omitted or if the instrument sits in any charging cradle or in a protective carry case which includes a power supply. The primary battery 25 for the instrument is shown in the rearward transverse portion of the instrument in Figures 2 and 4. Additional small batteries may be provided inside the instrument to maintain a system clock, memory of settings, etc.

Also shown in figure 4 is a set of additional thumb-activated controllers 26 on the uppermost rearwards facing surface on the instrument 27. These controllers are shown as sliders, but again can include any similar devices or a combination of devices such as buttons, joysticks, sliders, touch pads, track balls, touch screens or the like.

The package of the musical instrument shown in figures 1 to 4 is compact and easy to play, so is practical for use as a general purpose instrument. However, other packages are possible and can be designed to better suit a particular situation or set of requirements.

Figures 5 to 7 show a second possible embodiment of electronic musical instrument according to the present invention. Like items are accorded like

reference numerals. The instrument includes a left hand digit-activated unit 33 and a right hand digit-activated unit 34 joined together by a hinge mechanism 35.

Another possible embodiment of such a hinge mechanism 35 is shown in Figures 8 and 9. Like items are accorded like reference numerals. This hinge mechanism includes a locking lever 36, shown in the locked position. If the lever is moved so that its length is parallel with the rest of the hinge mechanism 35, the angle between the two units 33 and 34 of the instrument can be changed freely. Returning the locking lever 36 to the position shown locks the hinge mechanism 35, maintaining a constant angle between the two digit-activated units 33 and 34.

Those familiar with hinges know that many hinge designs exist which could be used to join the digit-activated units 33 and 34.

The inclusion of a hinge makes the present invention both easier to learn and easier to play.

When the two digit-activated units 33 and 34 are unfolded as shown in Figure 7, the two finger activated control surfaces are substantially coplanar. This allows the player to see all of the available finger-activated control surfaces, just as pianist can see all of a piano's keys when playing. This makes the location and selection of individual buttons easier for novices to learn.

Observe that, with the hinge mechanisms 35 shown, changing the angle between the digit-activated units 33 and 34 does not change the angle between a given unit's finger activated control or surface (10 or 11) and thumb-activated control surface (14 or 15). That is, the relationship between a player's thumb and fingers does not change when the instrument is folded to one degree or another. Therefore the thumb-finger coordination learned most easily when the instrument is unfolded into an open position is directly applicable when the instrument is folded into a closed position or any intermediate position.

When the left and right hand units are folded together as shown in Figures 5 and 6, the instrument is played in a similar fashion to the instrument shown in Figures 1 to 4, with the instrument usually resting on the player's lap or being

suspended by a strap from the player's neck and shoulders or supported from the player's torso, waist, arm, or wrist. This form factor is similar to a concertina in terms of the player's finger movements and hand positions.

Just as the present invention's unfolded position has ease-of-learning advantages, the folded position as shown in Figures 5 and 6 has ease-of playing advantages, relative to a non-hinged version that is fixed in the open position shown in Figure 7. The more compact form makes it easier to support, stabilize, and position with the digits/hand/arm, and therefore easier to play.

Thus having a hinge mechanism 35 joining the digit-activated units 33 and 34 makes the present invention both easier to learn and easier to play.

There is no display illustrated on the electronic musical instrument shown in Figures 5 to 7. Instead, as for any embodiment of the electronic musical instrument, the input controllers can be connected by a cable or wirelessly to another device. The other device can be a Personal Digital Assistant (PDA) which is used as the display device for the electronic musical instrument. The other device can alternatively be a mobile phone, Personal Computer (PC) pocket PC or any other device with a display and/or a polyphonic sound generating capability. One particularly useful alternative is the tablet PC which can be used to display sheet music at full size in addition to providing a Graphical User Interface (GUI) for control of the electronic musical instrument. Indeed with sound generating chips emerging having 64-note polyphony and a compact package (for use in mobile phones) the electronic musical instrument can be an input controller (generating music note values and music effect values) without the need for any on-board sound generating hardware to be provided. If a PDA or other external device is used to display an external GUI for the musical instrument, there can still be at least one display provided on the actual instrument to enable the instrument to be used as a stand-alone unit or to give simple feedback of settings and the like to the user.

Each digit-activated unit (33 or 34) includes a finger activated control or surface (10 or 11) and a thumb-activated control surface (14 or 15). The finger-

activated control surface (10) for the left hand is shown in this case as a button-field 42. Two additional finger-activated buttons 43 are also shown on each finger-activated controller, outside of the finger-span button-field of note-identifying buttons. These can perform any desired user assignable functions, send music note values, per-field effect values, or be preset to perform tasks such as shifting the predetermined music note values generated by the buttons (42) of the main array by a chosen interval (such as a semi-tone for transposing or one or more octaves for shifting registers). An alternative use for the additional finger-activated buttons 43 is to control effects such as illumination on/off or style of illumination for the finger activated controllers or the whole instrument.

Each thumb control region 14 and 15 is exemplified incorporating a thumb stick 44 and five thumb wheels 45. The thumb sticks can act as digital or analogue 2-axis controllers or joysticks and further include a digital switch activated by depression of the thumb stick 44. The thumb sticks may alternatively produce a variable or analogue signal indicative of the force applied to depress the thumb stick. The thumb wheels 45 are single-axis controllers, (usually analogue) and can be designed to produce a digital or variable signal when depressed.

Figure 10 shows a possible circuit block diagram for the electronic musical instrument of figures 5 to 7, showing the battery pack 80 (and/or the jack for an optional external battery pack), line power connectors 81, (optional) charger 82, DC/DC converter 83, boot micro-controller 84, and data bus 85.

A multi-purpose carrying case can be provided for any embodiment of the electronic musical instrument of the present invention. Figure 11 shows a multi-purpose carrying case 66 for the electronic musical instrument shown in Figures 5 to 7, although it can be adapted to suit any electronic musical instrument according to the present invention. The case 66 is designed to open into two halves 67 and 68 which are either hinged or separable, there being at least one speaker 69, 70 in each half of the case. Additionally, the case can include storage areas, pockets, clips, moldings and the like to accommodate the instrument and any accessories, cables,

music, a tablet PC, or anything else that accompanies or is used with the instrument. For example, a PDA, 71, is shown housed in an area inside the case. If any device such as a PDA or tablet PC is used with the instrument and the case, it can provide many functions such as sound generation, a display, and it is preferably also used to act as the host for those wired or wireless communication systems which require a host device.

To ease transportation of the case 66, wheels and handles can be provided (not shown). The design of the wheels and handle can be similar to that commonly found on most suitcases. The handle can be extendible or telescoping, and could include, in some embodiments, an antenna for wireless communication with the instrument. The handle can even be used either in its normal position, or clipped into a new position on the case to provide a music stand function for holding sheet music, a PDA, tablet PC or any other device used with the electronic musical instrument. Alternatively a purpose built stand or holder can be included in the design of the case. The stand can include a power connection to accept the PDA or tablet PC or the like or any other wires or clamps for any other devices such as microphones which can be used together with the musical instrument and case.

Figure 12 shows a possible embodiment of the electronic functionality housed within case 66. It can include a charging unit 104 for the instrument and/or a power supply 105 for converting power (ideally from a variety of sources such as from the mains 103 at 110 or 240volt AC or any DC supply such as a 12 or 24 volt car battery) to supply the charger 104, the musical instrument directly 106, or any other associated electronics. The case can even include a battery 102 for providing power to any electronics in the casing and/or to the instrument. Examples of the associated electronics that are preferably built into the multi-purpose carrying case 66 are an amplifier 111 and one or more speakers 69 and 70. The case can even include a tone generator, audio and data input and output connectors and can incorporate a wireless communication device 112.

Dynamic and Static Button-Arrangements

Acoustic keyboard instruments such as the piano and organ, and acoustic button-field instruments such as the concertina and chromatic button accordion, have static button-field arrangements. That is, the size, shape, and spacing of their (physical) note-controlling buttons (or keys) is determined at the time of manufacture.

An electronic instrument can also have this same kind of static arrangement of physical buttons. Alternatively, being electronic, it could have a more dynamic arrangement of "virtual" buttons on its at least one button-field.

The use of static buttons brings benefits and disadvantages. Static buttons, being physical, can provide tactile and kinaesthetic feedback to the player regarding the position of the fingers on the control surface. The primary disadvantage of a button-field composed of static buttons is a lack of flexibility.

Alternative control surfaces (10) are possible which are more flexible and adaptable than a fixed button-field composed of individual sensors. Many provide the ability to sense several points on a two dimensional surface with high resolution. This allows for the surface to be electronically "divided" up, providing a virtual button-field of any desired arrangement and/or layout. Also, a mix of note-controlling buttons and other virtual inputs or controls could be programmed in.

One possible embodiment of a dynamic button-arrangement is, for example, a contact and/or pressure sensing fabric.

Another possible embodiment of a dynamic button-arrangement is a touch-sensitive display. This embodiment would have the advantage of displaying visually the regions of the control surface that were associated with each button. Such a display, if general-purpose, could optionally be used as an interactive display of any kind of data, whether in performance mode or in other modes.

Dynamic button-arrangements would, in currently-known embodiments, be unable to provide tactile or kinaesthetic feedback to distinguish a given button from another, or from a non-button surface region. Overlays could be provided for known alternative button-arrangements, each with surface features such as finger-tip sized

concave regions, raised portions, or the like, to help the player locate and manipulate the desired buttons.

The overlays can have text incorporated to denote the function of particular discrete areas of the control surface. The overlays can also include illumination which can take many forms and be used for many purposes. For example, as a learning tool, the overlay can be made to change colour or luminescence on or around one or more discrete areas on the control surface to indicate that the player should touch the surface in the area(s) indicated. The overlay can be made to change colour or luminescence on or around one or more discrete areas on the control surface in response to contact or pressure at the one or more discrete areas. The overlay can be made to illuminate in different ways in response to the signals generated by the control surface, audio signals, randomly, or in any pre-programmed way. Alternatively, or additionally, the overlay can be a display surface capable of displaying any desired images or information, including the division of the control area into discrete input areas such as virtual buttons or any other inputs such as sliders, and text indicating the assignment of each discrete input area.